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Determination of mixed gas permeability of high free volume polymers using direct mass spectrometric analysis of the gas compositions

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In the present work the mixed gas permeability of polymeric membranes is determined with an instrument (see Figure 1) which uses direct mass spectrometric analysis of the gas composition without the prior gas chromatographic separation. Transport properties of dense polymeric membranes either in flat film configuration or in the form of hollow fibres are measured. The instrument consists of a differential permeameter with a sweep gas (helium or argon) on the permeate side, adjustable pressure on the feed side of the measured membrane and adjustable stage cut. The detector is a mass spectrometer with an inert quartz column, which analyzes complex mixtures by appropriate deconvolution of overlapping signals. This offers the advantage of potentially much faster measurements than in the case of for instance gas chromatographic analysis of the gas composition and may open the possibility to study transient behaviour in gas mixture permeation. The measurements are conducted at 25°C with the possibility to change the temperature.

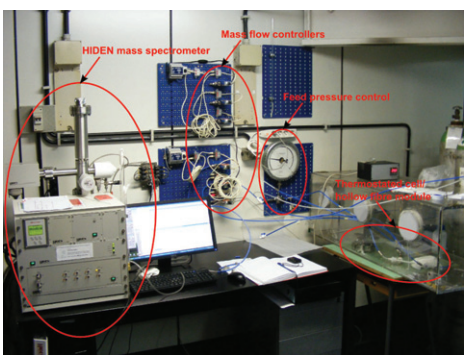

Figure 1: Currently constructed instrument for mixed gas separation

The membranes used in this work are the polymers of intrinsic microporosity (PIM) [1]. These novel membranes are intensively studied for their unique properties, exhibiting an excellent ratio between permeability and selectivity, in some cases exceeding the so-called upper bound established in the Robeson plots [2]. Most studies reported in the literature are limited to the determination of the ideal separation factors i.e. the ratio of permeabilities of pure gases of the desired gas pair. The pure gas behaviour and ideal selectivities will be compared with the behaviour of these membranes in real mixtures.

The work will be focused on industrially important gas saparations with mixtures containing O_2, N_2 and/or CO_2. Mixtures of these gases were supplied in a cylinders with precisely made mixtures. The future intension is to use the pure gases and prepare the mixtures by setting the

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desired composition using a set of mass flow controllers. The feed pressures were chosen in the range from 100 to 800 kPa.

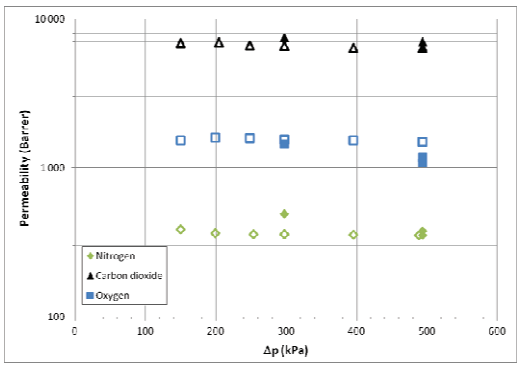

Figure 2: Gas permeability of EATB-PIM; comparison of pure gases (open symbols) and in a mixture of 35% CO_2, 55% N_2 and 10% O_2 (closed symbols)

Figure 2 shows the first results obtained from the new apparatus. In this case a nearly constant permeability with respect to the feed pressure was found for both pure and mixed gases. The permeability of mixed gases is close to that of pure gases.

Some discrepancies were observed in comparison with results obtained from a barometric fixed volume pressure increase instrument. This is related to the completely different measurement principle and operation conditions in the two instruments.

Since the investigated materials are very sensitive to the sample history and the operational conditions, these aspects will be studied in detail.

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Keywords: mixed gas permeability, polymer of intrinsic microporosity (PIM), mass spectrometric analysis